DAΦNE-Light

Making the invisible visible

Syncrotron Radiation Facility at the Laboratori Nazionali di Frascati

Istituto Nazionale di Fisica Nucleare
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WHAT IS SYNCROTRON RADIATION?

Synchrotron radiation is the electromagnetic radiation generated by the acceleration of charged particles, moving near the speed of light, through magnetic fields.
When electrons (or any charged particle), like the ones circulating in the DAΦNE storage rings, are accelerated to keep them in a circular path using bending magnets, they radiate electromagnetic radiation in a narrow cone in the direction they were traveling (Fig. 1).

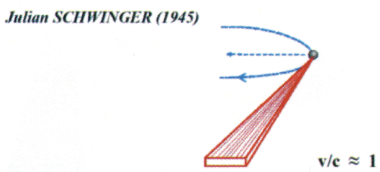

Fig. 1. Synchrotron radiation emission by charged particles moving in a circular path at a speed, v, comparable with the speed of light, c, is based on the laws of electromagnetism.

This radiation (Fig. 2) is called **synchrotron radiation** because "**synchrotron**" is the name given to any circular accelerator that uses microwave electric fields for acceleration and magnets for steering.

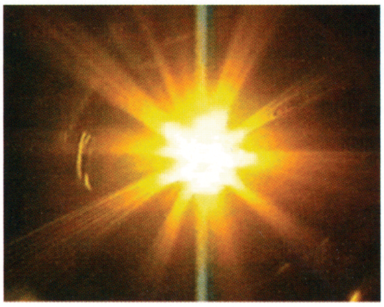

Fig. 2. Synchrotron radiation emerging from a beam port of DAΦNE.

HOW CAN BE PRODUCED?

Synchrotron radiation can be produced artificially in storage rings or naturally by fast moving electrons accelerated by magnetic fields in space (Fig. 3).
Concerning storage rings, synchrotron radiation can be produced in the large dipole **bending magnets** that steer the beam around and also in magnetic **insertion devices** called "**wigglers**" and "**undulators**".

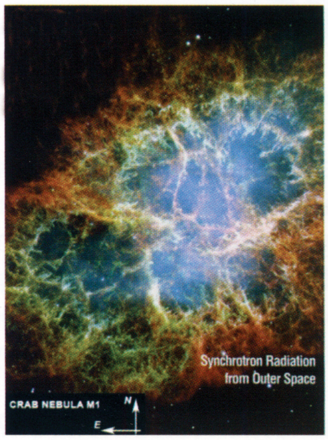

Fig. 3. Crab Nebula viewed by the Hubble Space Telescope in the visible range. In this image the pale blue emission in the interior of the nebula is synchrotron emission. Image from NASA-ESA.

These insertion devices are periodic arrays of magnets inserted between the dipole magnets that cause the electron beam to bend back and forth, greatly enhancing the intensity of the radiation and/or extending the spectral range to higher X-ray energies (Fig. 4).
All the instrumentation used to carry the syncrotron radiation beams from the storage ring to the experimental and stations, included, takes the name of beamline.

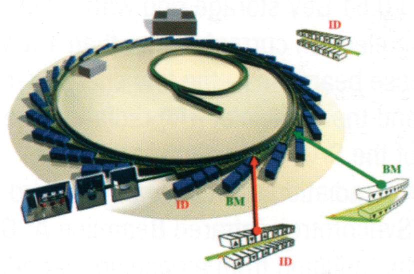

Fig. 4. Schematic view of a storage ring and beamlines having as sources bending magnets (BM) and insertion devices (ID).

A typical beamline includes three hutches one housing the optical elements, one the experimental apparata and the last one all the control systems (Fig. 5).

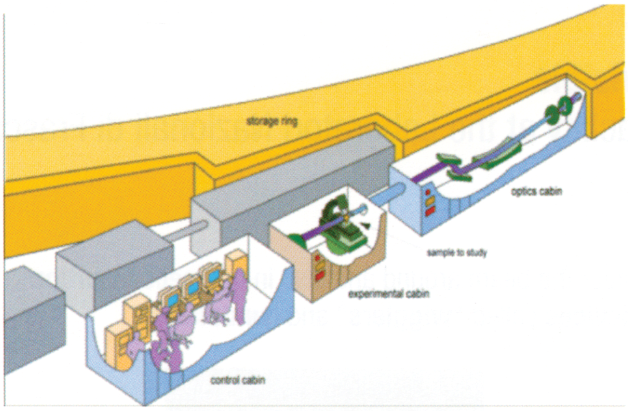

Fig. 5. Enlarged schematic view of a synchrotron radiation beamline.

Synchrotron radiation has several unique properties, for example high intensity, that makes it an extraordinarily powerful tool for basic and applied research and technology. The spectral range covers the part of the electromagnetic spectrum between the infrared radiation and the high energy X-ray (Fig. 6).

WHAT IS SYNCROTRON RADIATION FOR?

The wavelengths of the emitted photons span from the **atomic level** to **biological cells size** (Fig. 7), thereby providing incisive probes for advanced research in **materials science**, **physical** and **chemical sciences**, **metrology**, **geosciences**, **environmental sciences**, **biosciences**, **medical sciences**, and **pharmaceutical sciences**; in particular the features of synchrotron radiation are especially well matched to the needs of **nanoscience**. **DAFNE-Light** is the Synchrotron Radiation Facility at the Laboratori Nazionali di Frascati. Three beamlines are operational since 2003 using in **parasitic** and **dedicated mode** the intense photon emission of DAΦNE, a 0.51 GeV storage ring with a routinely circulating electron current higher than 1 ampere. Two of these beamlines - the low energy X-ray line (DXR-1) and the ultraviolet (UV) radiation line (DXR-2) use one of the DAFNE wiggler magnets as synchrotron radiation source, while the third beamline SINBAD (**S**ynchrotron **In**frared **B**eamline **A**t **D**AΦNE) collects the radiation from a bending magnet and was the first Italian synchrotron radiation beamline operating in the infrared range. New **XUV** (low energy X-ray and ultraviolet radiation) bending magnet beamlines are nowadays under construction.

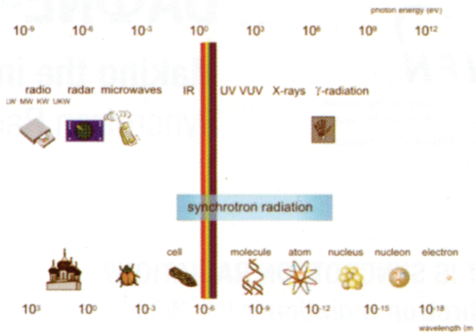

Fig. 6. Electromagnetic spectrum and synchrotron radiation spectral range.

INFN and, in particular LNF, has a long standing tradition in using synchrotron radiation for interdisciplinary studies, which has been developed in more than 10 year experience using ADONE, the previous accelerator operating in Frascati, as synchrotron radiation source.

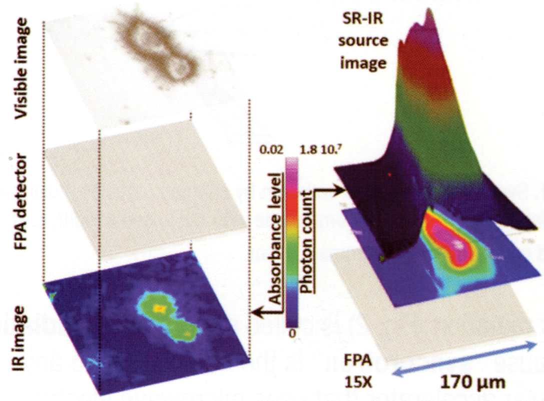

Fig. 7. Left panel: Visible image and infrared spectral mapping on a single cell of rat glioma giving the biodistribution of collagen types within healthy and dystrophic connective tissues. Right panel: Reconstruction of the IR DAFNE source illuminating a FPA detector.